CURRENT LITERATURE

BOOK REVIEWS

The root-fungi of orchids

BURGEFF[1] has brought together the extended results of his own research and those of other students upon the root-fungi of orchids. The volume contains a comprehensive citation of literature, several tables summarizing results of experiments, and discussions of the theory of the mycorhiza question. By way of introduction, BURGEFF defines his use of the word symbiosis as that relation of two symbionts in which one aids the other in any way, if only to make existence possible under conditions otherwise impossible. After union, the two organisms form a new organism, a unit, which takes up the struggle for existence under new conditions, each being a body member. Such is claimed to be the condition of the orchids and their root-fungi. The two sections of the work are as follows:

1. *The study of the fungus independent of the plant.*—On a culture medium of agar and rain water with a slight trace of starch, 29 root-fungi, aseptically obtained from native and tropical orchids, were grown (holosaprophytic ones were unsuccessful). Such species of *Orcheomyces*, as the author chooses to call the fungi for convenience, are described in detail as to their structure and behavior in the culture. For the first time a study of their enzymes has been made, and the endophytes were grouped accordingly on the basis of their biological relations to the orchids. In general they have thin-walled, regularly septate mycelia; the hyphae are sharply differentiated into *Langhyphen* that branch little and show unlimited growth in one direction, and *Kurzhyphen* that are of smaller caliber and arise at regular intervals and whose cells under certain conditions are transformed into spores (*Sporenträger*) or absorptive hyphae (*Sanghyphen*). In old age spores and hyphae contain a fatty oil. Chains of hyaline or slightly colored spores may unite into loose clusters or closer sclerotia-like groups. All fungi fuse or anastomose in some manner. The hyphal cells contain two to ten nuclei, but the spores contain only two nuclei. Spiral knots initiated in cultures by the surface tension of a drop of water at the tip of the hypha are comparable to those in the root cells developed in response to the pressure of the resisting plasma membrane to the penetration of the hypha. No sexual reproduction was observed.

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[1] BURGEFF, HANS, Die Wurzelpilze der Orchideen; ihre Kultur und ihr Leben in der Pflanze. 8vo. pp. 207. *pls. 3. figs. 38.* Jena: Gustav Fischer. 1909.

———, Zur Biologie der Orchideen Mycorhiza. pp. 66. Inaug. Diss. Jena: Gustav Fischer. 1909.

Of the carbohydrate culture media, starch, maltose, and saccharose were best; glucose and dextrin next; and glycerin poorest. Correspondingly, all fungi possessed diastase and emulsin; some invertase and maltase; some aesculin; one tyrosinase; and only one cytase. In humus decoctions all grew well.

The endophytes cannot assimilate free nitrogen. They belong to BENNECKE's category of "Ammon-nitrit-nitratpilze," and grow luxuriantly, forming spores on ammonium salts, ammonium nitrate holding first place. Organic N compounds were varyingly well assimilated. Peptone produced splendid growth, and salep furnished sufficient N for all to grow. All fungi possess proteolytic enzymes.

The production of acid in assimilation is slight, and in general, in media containing asparagin, peptone, or urea, is in proportion to the intensity of the growth. Orchid fungi require to a high degree atmospheric oxygen, dying in long-continued anaerobic cultures. The formation of spores and spore sclerotia depends upon the concentration of the medium, its exhaustion, and the amount of assimilation products present. Salep always stimulated spore-formation, as did increased transpiration.

2. *The study of the plant and the fungus.*—For the biological relations of the plant and the fungus, BURGEFF chooses the terrestrial orchid *Epidendrum* (*dichromum?*) and the hybrid epiphyte *Laelio-Cattleya*. Without a fungus, seeds of *Epidendrum*, on a culture medium of rain water, 2 per cent salep, and 1.5 per cent agar, did not germinate. With ten different fungi they germinated within 25 days. The embryo did not become green until infected. Thinned nutritive agar cultures with fungi produced stouter plants than the rain water cultures. The stages of development and limits of the fungus agree with the *Cypripedium* type of development described by BERNARD. Infection takes place through the suspensor at first, and later through the root hairs, passing by means of the *Durchlasszellen* into the cortex. The hyphae of the sub-epidermal layer (*Pilzwirtzellschicht*) are never digested, but *Eiweisshyphen* appear in the digestive layer beneath. The cytological facts agree with the phenomena of digestion, where the remains (a clump) are surrounded by a cellulose layer (*Haut*), and the nucleus assumes the resting stage, ready to digest new hyphae. Clumps may become several-layered.

BURGEFF found that the seeds of *Laelio-Cattleya*, wettable only after three or four days, could germinate, become green, and attain considerable differentiation (stomata at apex, rhizoids at base, leaf primordia) in three or four months. A resting period of a year is necessary before growth continues, for which also a fungus is required. Just before infection, the oil in reserve in the cells near the suspensor is transformed to starch, which disappears, however, as soon as the fungus penetrates the cells. Both embryo and fungus show evidence of growth, the latter by the formation of *Eiweisshyphen* (homologous with spores and hyphal knots).

Testing the possibility of saprophytic germination in *Laelio-Cattleya*,

BURGEFF obtained its development, in 0.33 per cent cane sugar with mineral salts on agar, in the dark, to the differentiation of papillae, and it lived ten months. Further development either in light or dark required the fungus. While in the light the orchid developed normally, in the dark it elongated and resembled the *Epidendrum* which grew in the weaker concentration of salts. BURGEFF concludes that physiologically the behavior of the fungus is alike in the germination of the epiphyte and the terrestrial orchid, and that the appearance of chlorophyll in the epiphyte is an adaptation to its life in the light.

Seedlings with the fungus in absence of CO_2 in the dark grew, but developed no root, while in the light the growth was normal. Experiments on the physiology of nutrition, where fungus and seedling were grown together, showed the best N sources to be ammonium chlorid and nitrate. Although asparagin was favorable for the fungus in free culture, the plant could not grow in it. In N-free media there was no development. Lactic acid (2 per cent) in mineral salt agar culture caused both plant and fungus to grow well. *Laelio-Cattleya* was found to harbor some fungi (17 tested) unable to stimulate its germination.

BURGEFF devotes 50 pages to the histological processes in the growing plants. These detail the places of entrance, position of the fungi, peculiar features in the plant cell (spores and clumps, *Klumpenbildung*), the emission of hyphae to the substratum, etc. Most of the fungi have mycelial connections with the outside substratum, therefore anatomically there is nothing to prevent ascribing to such hyphae the function of conduction of soluble materials. The author explains the unwettability of the seeds as due to the *Luftbläschen* in the netted testa itself, and to the air between the testa and embryo (comparable to the condition in the lycopod spores). Such unwettability hinders the passage of spores through the soil, contrary to the theory of KOCH and LÜSTNER, but is of advantage in preventing the clinging together of seeds in the capsule, therefore an adaptation to their dissemination by wind. Also because the seeds are chemically attracted to the fungi, the unwettability is an adaptation in terrestrial orchids against too rapid exhaustion of this substance.

BURGEFF agrees with BERNARD in the probable steps of development of the symbiosis by way of parasitism, but would speak of the association not as a "maladie bienfaisante," but as of "einem glücklichen Zusammentreffen verschiedener Umstände." He bases this remark on the following facts: the fungus is harmless, its enzymatic qualities separating it from comparison with parasites with toxic qualities; it is able to kill an unadapted fungus whose penetration it nevertheless allows; its fitness for infection is seen in the *Durchlasszellen* of the embryo. A mutualistic symbiosis demanded by the definition is found in this association, for the orchid has to thank the fungus for its existence, and the fungus is grateful to the orchid for the materials difficult to obtain from the soil which enable it to form spores. As to the materials of exchange between the components, the question is left unanswered; but the idea of conduction of mineral salts is favored, because of the results of the

cultural experiments and because of the detailed morphological and anatomical features of both symbionts. The fungus causes the conversion of starch into sugar by its diastase. Its function results from its enzymatic quality, which, with the solution of carbohydrates in the plant cell, induces the development of the seed, not by bringing soluble materials to the cell, but by transforming substances already there. BURGEFF suggests here the unproven fact of diffusion of the diastatic enzyme out of the fungal hypha through the *Plasmahaut* into the plant cell. This may also occur in the substratum from the emission hyphae. The osmotic relations arising from the sugar solutions could account for the absorption of water, but if nutritive salts are absorbed from the fungi from outside, a rapid change in permeability and adjustment of pressures at just the proper time to seize the salts brought by the fungus must take place.

On the whole, the relations between the plant and the mineral salts of the soil are of striking importance for the origin and maintenance of the orchid symbiosis. Although the structures show a gain in nitrogenous substances, the habitats of orchids, and cultural experiments exclude the possibility of free N-absorption. No anatomical features can prove the absorption of organic carbohydrates; although diastase and emulsin are common to all fungi, material for the action of the former is lacking in the soil, and we are in ignorance concerning the substance in the soil digested by the latter. Any substance taken up by the plant, either through its roots or by means of the fungus, must first be made soluble by the fungus itself, or by its exoenzymes in the substratum.—GRACE L. CLAPP.

MINOR NOTICES

Farm weeds.—The preparation of a scientific manual for the use of the ordinary layman is admittedly a difficult task, but it has been successfully accomplished by CLARK and FLETCHER,[2] whose volume upon farm weeds is the best that has yet appeared upon this subject. The remarkable simplicity without the sacrifice of scientific accurracy is due largely to the splendid ability of the late Dr. JAMES FLETCHER, who thus adds one of the latest of his many valuable contributions to botany and agriculture. More than 200 of the more troublesome weeds of Canada are arranged according to modern botanical classification, with very complete scientific and common synonyms, and briefly but accurately described in non-technical language. Special attention is directed to the characteristics which make the various plants troublesome as weeds, and careful directions are given for the most practicable and successful methods of control and extermination.

The most valuable aid to the recognition of different species is a series of 76 full-page plates, colored with the greatest accuracy. They include

[2] CLARK, GEORGE H., and FLETCHER, JAMES, Farm weeds of Canada. Second edition. 8vo. pp. 192. *pls. 76.* Ottawa: Department of Agriculture, Dominion of Canada. 1909. $1.00 (single copies only, for sale by Superintendent of Stationery, Government Printing Bureau, Ottawa).